Mr. Gassiot was present on one occasion, and particularly observed with myself the rapidity with which a series of 12 large Leyden jars arranged in cascade were discharged. The noise was great; and each time the spark (which was very condensed and brilliant) struck the metallic disk, the latter emitted a ringing sound, as if it had received a sharp blow from a small hammer.

The discharges were made from a point to a metallic disk; and when the former was positive the dense spark measured from $18\frac{1}{2}$ to $18\frac{3}{4}$ inches, and fell to $8\frac{1}{2}$ inches when the metallic plate was positive and the point negative.

A variations of the Leyden-jar experiments was tried, by connecting the coil worked by a quantity battery of 25+25 cells with six Leyden jars arranged in cascade; and the spark obtained measured $8\frac{1}{2}$ inches.

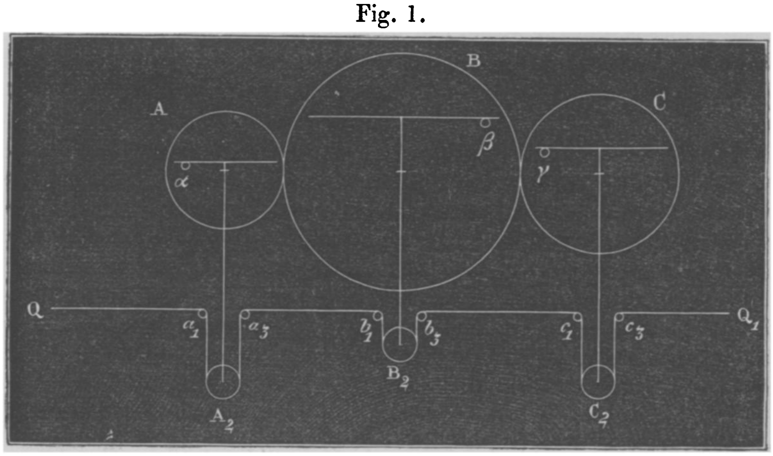
The same six jars connected with the coil when the 50 cells were arranged continuously for intensity gave a spark of 12 inches of very great density and brilliancy.

Other experiments are being tried with the great coil, the results of which will be duly brought before the Society if thought of sufficient importance.

XXVIII. "On the Mechanical Description of Curves." By W. H. L. Russell, F.R.S. Received June 17, 1869.

Let A, B, C be three wheels rolling in one another (fig. 1); they may of course be supposed to describe simultaneously the angles $m\theta$, $n\theta$, $r\theta$, when m, n, and r are constant.

Fig. 1.

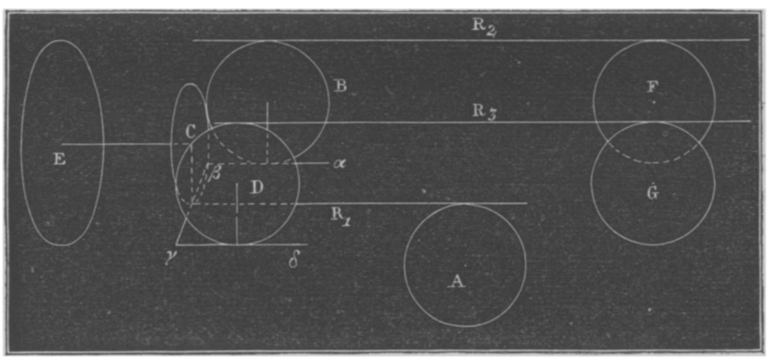


Let α, β, γ be three nuts situated on A, B, C respectively, at distances a, b, c from their centres. Then if these nuts work in horizontal bars (as exemplified in many sewing-machines), the bars will descend vertically

through the spaces $a \sin m\theta$, $b \sin n\theta$, $c \sin r\theta$ respectively. We may combine all these vertical motions together; for if vertical rods be attached to the horizontal bars, and a cord fixed at Q pass over the pulleys a_1, A_2, a_3 b_1, B_2, b_3, c_1, C_2, c_3, as shown in the figure, the other extremity Q_1 will describe the space $a \sin m\theta + b \sin n\theta + c \sin r\theta$. By this contrivance we are able to combine any number of vertical descents, so that it is readily seen that $a \sin (m\theta + \alpha) + b \sin (n\theta + \beta) +$ &c. may be described mechanically. A machine on the same principle as this had been previously invented by Mr. Bashforth.

I soon perceived that in order to describe the general equation of the *rth* order by continued motion, it was necessary to make a wheel revolve through an angle equal to the sum and difference of the angles described in the same time by two given wheels; to effect this I invented the apparatus shown in fig. 2.

Fig. 2.



In fig. 2 let A be a vertical wheel working truly in a horizontal rack R_1, which propels the horizontal frame α, β, γ, δ. On this frame stand the wheels B and D parallel to the plane of the paper. The wheel C, supposed perpendicular to the plane of the paper, works by teeth in the wheels B and D, and the four wheels A, B, C, D are precisely equal.

To the centre of C is attached a square axis, which passes through the centre of the wheel E, so that the wheel E in revolving may, without changing its plane, communicate motion to C as the frame moves forward. Two horizontal racks, R_2, R_3, parallel to the plane of the paper, are urged by the wheels B and D; and these, again, work in the fixed wheels F and G, equal to A, B, C, D in all respects. Then if the wheel A describe in a given time the angle θ, and the wheel E in the same time the angle ϕ, the wheels F and G will revolve respectively in the same time through the angles $\theta + \phi$ and $\theta - \phi$.

We shall call the wheel A an abscissa wheel, the wheel E, an ordinate wheel, for reasons which will appear directly, also F an addition wheel, and G a subtraction wheel.

Let $x=a \sin \theta$, $y=a \sin \phi$, then the general equation of the rth order may be written

$$\alpha \sin (m\theta+n\phi)+\alpha' \sin (m'\theta-n'\phi)+\alpha'' \sin (m''\theta+n''\phi)+\ldots =a \sin \theta.$$

Let a number of machines like the foregoing be placed side by side with their ordinate wheels rolling in one another, and their abscissa wheels duly connected. Let one abscissa wheel describe an angle $m\theta$, and the corresponding ordinate wheel the angle $n\phi$, then a nut placed on the corresponding addition wheel, at a distance α from its centre, will cause a horizontal bar to descend vertically through a space $\alpha \sin (m\theta+n\phi)$. In the same way a nut properly placed on the subtraction wheel will cause a horizontal bar to descend vertically through a space $\alpha' \sin (m\theta-n\phi)$. By means of the adjacent machines we may in like manner cause bars to descend through the vertical spaces, $\alpha'' \sin (m'\theta+n'\phi)$, $\alpha''' \sin (m'\theta-n'\phi)$, &c. Now let motion be communicated to the ordinate wheels, and let all the vertical motions due to the addition and subtraction wheels be combined together and made to act vertically upon a nut in one of the abscissa wheels; then the angles θ, ϕ, will satisfy the equation

$$\alpha \sin (m\theta+n\phi)+\alpha' \sin (m\theta-n\phi)+\alpha'' \sin (m'\theta+n'\phi) \ldots =a \sin \theta,$$

which is the general equation of the rth order.

Therefore two bars moved respectively horizontally and vertically by nuts in the wheels describing the angles θ and ϕ will trace by their intersection the required curve.

COMMUNICATIONS RECEIVED SINCE THE END OF THE SESSION.

I. "Spectroscopic Observations of the Sun."—No. V. By J. NORMAN LOCKYER, F.R.S. Received July 8, 1869.

Since the date of my last communication under the above title the weather has, if possible, been worse for telescopic work than during the winter and spring; my opportunities of observation, therefore, have been very limited: still the sun has occasionally been in such a disturbed state, and our atmosphere has at times been so pure, that several new facts of importance have come out.

I will state them here as briefly as possible, reserving a discussion of them and my detailed observations for a future occasion.

I. The extreme rates of movement in the chromosphere observed up to the present time are:—

Vertical movement	40 miles a second
Horizontal or cyclonic movement .	120 ,,

II. I have carefully observed the chromosphere when spots have been near the limb. The spots have sometimes been accompanied by prominences, at other times they have not been so accompanied. Such observations show that we may have spots visible without prominences in the same region,